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U. S. COMMISSION OF FISH AND FISHERIES,
GEORGE M. BOWERS, Commissioner.

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ARTIFICIAL PROPAGATION

OF THE

SALMONS OF THE PACIFIC COAST.

Extracted from the Revised Edition of the Fish Manual.
Pages 1 to 15, Plates 3 to 10.

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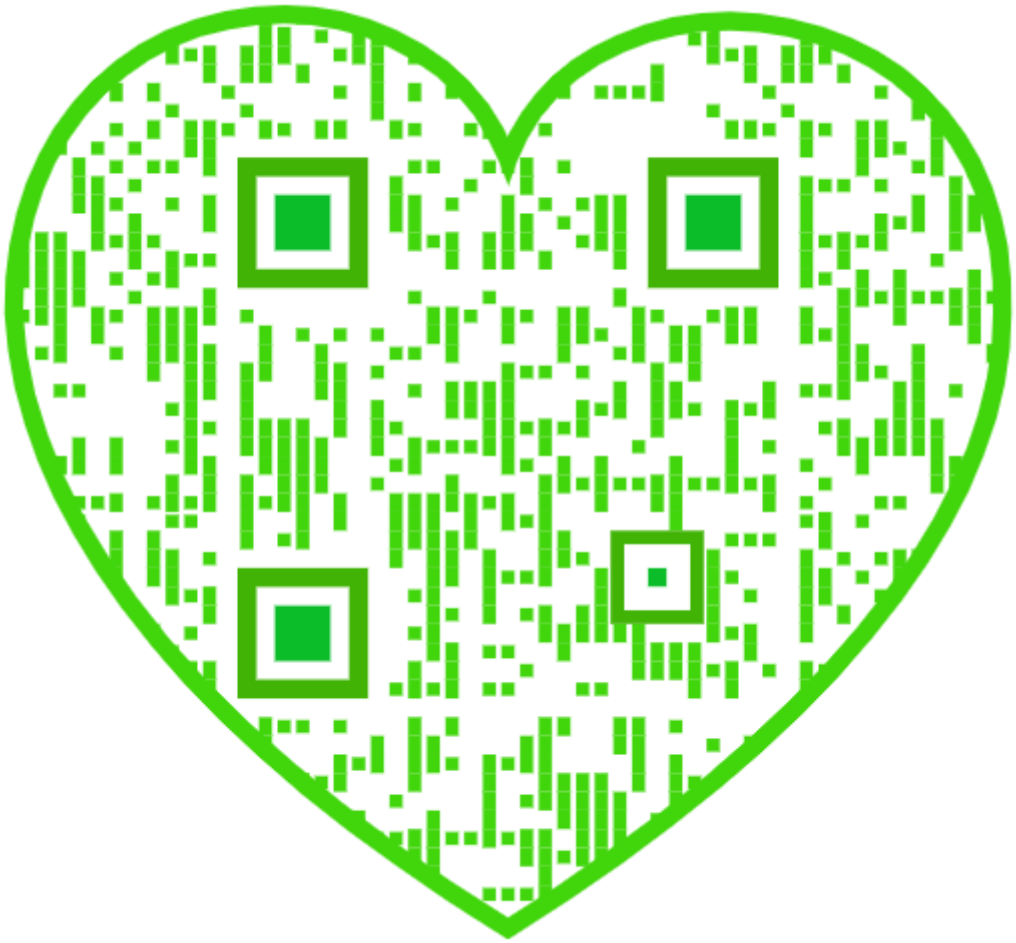

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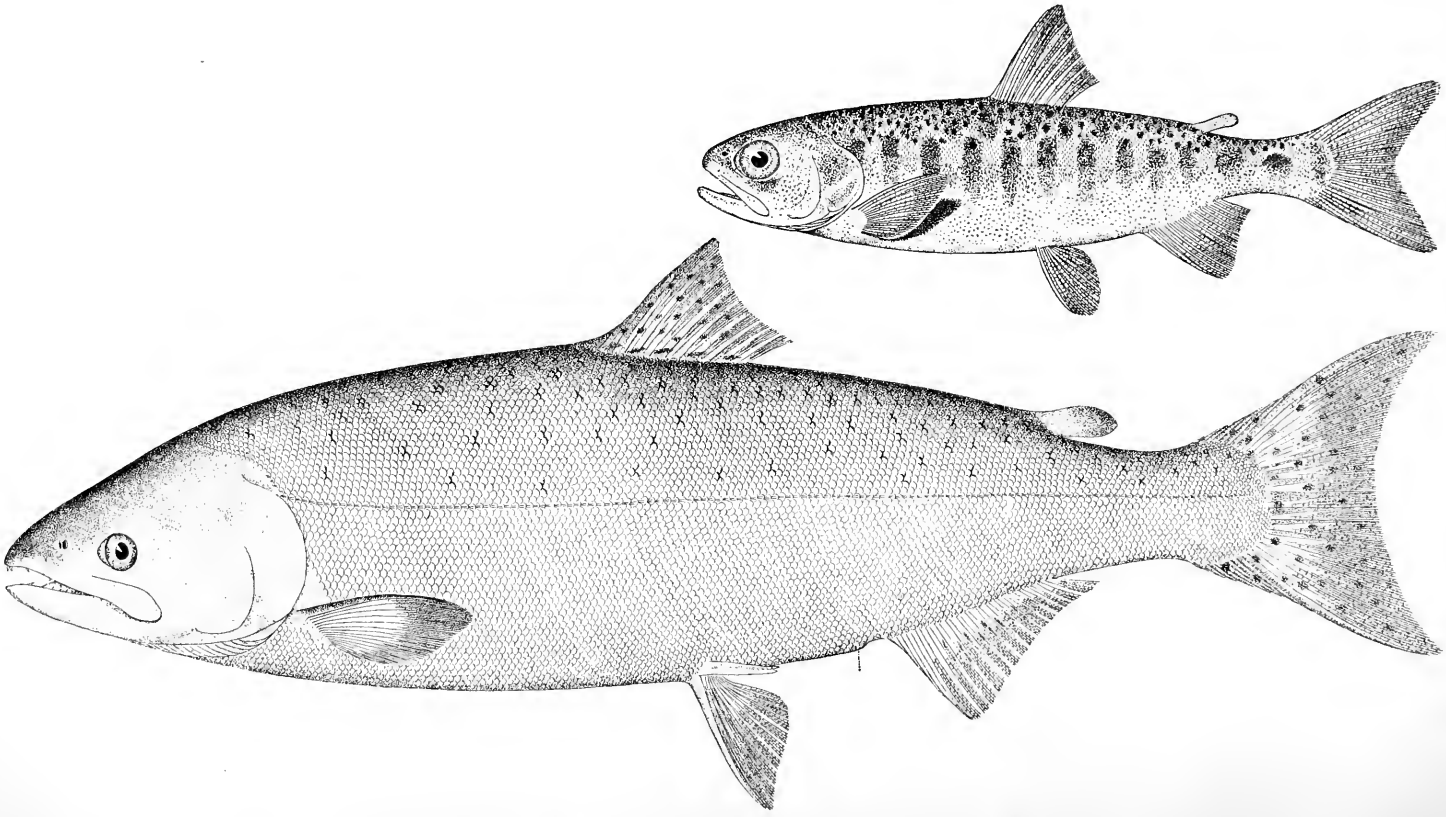


ONCORHYNCHUS TSCHAWYTSCHA. *Quinnat Salmon; Chinook Salmon; King Salmon.*
The upper figure is drawn from a young example, 4 inches long.

THE SALMONS OF THE PACIFIC COAST.

There are five species of salmon on the Pacific coast which belong to the genus *Oncorhynchus*, namely, the chinook or quinnat salmon (*Oncorhynchus tschawytscha*), the red or blueback salmon (*Oncorhynchus nerka*), the humpback salmon (*Oncorhynchus gorbuscha*), the silver salmon (*Oncorhynchus kisutch*), and the dog salmon (*Oncorhynchus keta*). The features which separate the Pacific salmons from the Atlantic salmon are not marked and consist chiefly in a larger number of rays in the anal fin, and more branchiostegals, gillrakers, and pyloric cœca.

The characters noted in the following key will usually be sufficient to distinguish the different species of Pacific salmon:

Quinnat salmon: Scales in longitudinal series from 135 to 155, averaging about 145; pyloric cœca 140 to 185; gillrakers comparatively short and usually 23 in number, 9 being above the angle; rays in anal fin 16; branchiostegals 15 to 19. Body robust; head conic; eye small; caudal fin deeply forked. Color above dusky, sometimes with bluish or greenish tinge; sides and belly silvery; head dark, with metallic luster; back and the dorsal and caudal fins with numerous round black spots.

Blueback salmon: Scales in longitudinal series about 130; pyloric cœca, 75 to 95; gillrakers comparatively long and 32 to 40 in number; rays in anal fin 14 to 16; branchiostegals 13 to 15. Body rather slender; caudal fin much forked; anal and dorsal fins low. Color, above bright blue, sides silvery, no spots.

Humpback salmon: Scales very small, 210 to 240 in longitudinal series; pyloric cœca very slender, about 180 in number; gillrakers short, about 28, 13 being above angle; anal rays 15; branchiostegals 11 or 12. Color, bluish above, silvery on sides; hind part of back, adipose fin, and tail with numerous black spots, largest and of oblong form on tail.

Silver salmon: Scales large, 125 to 135 in longitudinal series; pyloric cœca comparatively few and large, 45 to 80 in number; gillrakers long and slender, 23 in number, 13 below angle; anal rays 13 or 14; branchiostegals 13 or 14. Body long; head short, conic; snout blunt; eye small; fins small, caudal deeply forked. Color bluish-green, sides silvery, finely punctulated; spots few and obscure on head, back, dorsal, adipose dorsal, and upper rays of caudal.

Dog salmon: Scales of medium size, 138 to 155 in lateral line; pyloric cœca 140 to 185; gillrakers short and few, 9 above and 15 below angle; 13 or 14 rays in anal fin; branchiostegals 13 or 14. Form of quinnat, but head longer and more depressed. Dusky above and on head, paler on sides; very fine spots on back and sides, often wanting; tail plain dusky or finely spotted, with black edge; other fins blackish.

These salmons are the most important group of fishes entering the rivers of North America. The steelhead (*Salmo gairdneri*), technically a trout, but popularly regarded as a salmon, also inhabits the waters of the Pacific coast and adds to the importance of the salmon tribe.

In recent years the annual catch of salmon in the Pacific States and Alaska has been over 100,000,000 pounds. In 1899 the quantity of salmon canned was 2,450,000 cases of 48 one-pound cans. The weight of the fresh fish represented by this pack, together with the large quantities sold fresh, salted, and smoked, was about 175,000,000 pounds, with a value, as placed on the market, of nearly $9,000,000.

THE QUINNAT SALMON.

The quinnat salmon (*Oncorhynchus tschawytscha*) is known by a number of other common names in various parts of its range; among them are chinook salmon, king salmon, Columbia salmon, Sacramento salmon, and tyee salmon. The quinnat is the most important of the salmons. It is not only superior in food qualities, but attains a vastly larger size, has a wider geographical range and a greater commercial value than any of the others. When fresh from the ocean it is a very handsome, resplendent, well-formed fish, greatly resembling the Atlantic salmon (*Salmo salar*), although its form is less symmetrical and its outlines less graceful. It is of a uniform rich red color, becoming paler or streaked upon the approach of the spawning season. Its value for canning purposes is largely enhanced by the persistence of the red color of the meat after cooking.

In size no other salmon in the world compares with it. In the Yukon River, Alaska, it reaches a weight of over 100 pounds, and in the Columbia River there are well-authenticated cases of its weighing more than 80 pounds. Farther south, it runs smaller, although in the Sacramento individuals weighing 50 or 60 pounds are not rare; 22 pounds is a fair average weight in the Columbia River and 16 pounds in the Sacramento.

Its known range is practically from Monterey Bay (latitude 36½) to the Yukon River, but individuals have been seen in Norton Sound, somewhat north of the Yukon, and as far down the coast of California as the Ventura River. Since it thrives well in very cold water it is likely that its range extends to and possibly within the Arctic Ocean.

While in the sea quinnat salmon probably do not wander very far from the mouths of the rivers they have left, and for this reason usually return to spawn in the rivers in which they were hatched. They prefer the larger rivers, like the Sacramento, the Columbia, the Nushagak, and Yukon. They are very persistent in ascending the rivers to spawn, and have been seen crowding up the rivulets which form the head waters of the Sacramento until nearly half their bodies were exposed to the air. No matter how far the headwaters of a river are from the ocean, some of the salmon will press forward until stopped by impassable obstructions or water too shallow for them to swim in. On reaching

the headwaters they remain for a week or two before proceeding to the spawning-grounds. Their rate of progress varies with the season, and probably depends to a great extent on the rainfall and the state of the river, rain, roily water, and high water always hastening their progress.

When they first come from the ocean the sexes are almost identical in appearance, but as the time for spawning approaches a difference is noticed between the males and the females, which during the spawning season becomes more marked. The fully developed ova of the female give her a round, plump appearance, while the male grows very thin. His head flattens, the upper jaw curves like a hook over the lower, the eyes become sunken; large, powerful, white, dog-like teeth appear on both jaws, and the fish acquires a gaunt and savage appearance. As soon as they reach fresh water their appetites grow less, their throats begin to narrow, and their stomachs to shrink. This does not at first entirely prevent them from feeding, but it changes them enough to enable them to overcome the temptation to return to their well-stocked feeding-grounds in the ocean, and the longer they remain in fresh water the greater are the changes, and the desire to turn back for food is correspondingly lessened. This change comes about gradually, increasing day by day from the time they leave tide water until at the near approach of the spawning season their throats and stomachs become entirely incapacitated for receiving food, and the desire and ability to feed leave them entirely. The great reserve of flesh and blood which they bring with them from the ocean enables them to keep the vital organs active until their mission up the fresh-water streams is accomplished.

Quinnat salmon that spawn a long distance from the ocean do not return to it again, but die on or near their spawning-grounds. This singular fact has been disputed, but its truth has been proved repeatedly and conclusively. After spawning they rapidly deteriorate, the flesh shades off to a light, dirty pink and they become foul, diseased, and much emaciated. Their scales are wholly absorbed in the skin, which is of a dark olive or black hue, and blotches of fungus appear on their heads and bodies, and in various places are long white patches where the skin is partly worn off. Their fins and tails become badly mutilated, and in a short time they die exhausted.

The quinnat salmon first appear on the Pacific coast at Monterey Bay, where many are caught with hook and line as early as the second week in January, and are next seen in the Sacramento River in numbers in February. In the Columbia River they appear in March, but are not abundant until April or May. They arrive in southern Alaska in May and farther north in June, while it is probable that it is still later before they ascend the Yukon, where the running season is very short and may not exceed a month or six weeks. The early runs in the Columbia River are usually from one to three weeks passing from the mouth of the river to Clifton, about 20 miles. They first appear at The Dalles, 200 miles up the river, in the middle of April, and are found

in great quantities at this point about the middle of June, two months after they appeared in large numbers at the bar. This would indicate that they proceed up the Columbia at the rate of 100 miles a month. In the later runs they probably travel faster.

The spawning season of the quinnat varies in different rivers and, considering the entire coast, lasts at least six months. In July the summer run is spawning at the headwaters of the McCloud and Sacramento rivers in California; in August and September, farther down these rivers. In October the fall run has begun in the McCloud and below and this run continues spawning through November into December. In the Columbia the spawning begins at the headwaters in June; at Clackamas, 125 miles from the mouth of the river, it begins about the middle of September and continues until November.

A few days before they are ready to spawn the salmon hollow out elongated cavities with their heads and tails in the gravel beds of the river where there is some current, and here in due time the eggs and milt are deposited. The eggs drift into the crevices in the pile of stones thrown up below the hollow, sink to the bottom, and remain in that protected position during incubation; here, also, the young remain until the umbilical sac is absorbed. The eggs and young are liable to destruction by freshets, but are comparatively safe from other injurious influences.

The quinnat is not so prolific as the Atlantic salmon, 300 or 400 eggs to each pound weight of the parent fish being a fair average.

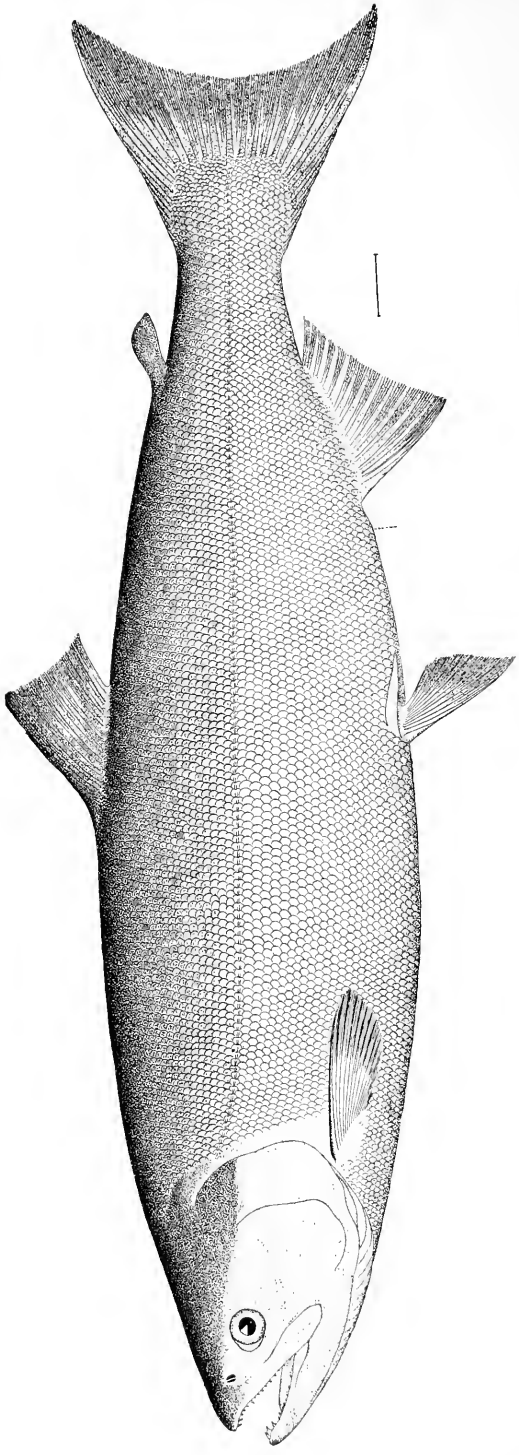
In view of the enormous annual catch of this salmon for commercial purposes the necessity for its propagation became manifest at an early period in the history of the Pacific fisheries. Fortunately it is readily susceptible of artificial propagation on a large scale, otherwise the supply in the western rivers would have materially fallen off. Since the work began in 1873 on the McCloud River it has grown to large proportions, and engages the attention of all the coast States as well as the General Government, and is now more extensive than ever before.

As the salmon ascend the rivers they are caught by gill nets, fyke nets, pounds, weirs, seines, wheels, and other devices, but in the Sacramento and Columbia the greater numbers are caught with gill nets drifting with the current or tide as they head upstream. In the rivers they are comparatively safe from enemies except otters, ospreys, and fishers, but immense numbers are destroyed at the mouths of the streams by seals and sea lions.

The quinnat salmon has been introduced into Japan, Australia, New Zealand, and Europe, but efforts to acclimatize it on the Atlantic coast of the United States have so far been unsuccessful.

THE BLUEBACK SALMON.

Considering the entire west coast, this species (*Oncorhynchus nerka*) is probably more numerous than all the other salmons combined. It is known in different regions under the names blueback, redfish, red salmon, Fraser River salmon, and sock-eye or saw-qui. It ranks next



ONCORHYNCHUS NERKA. *Blueback Salmon; Redfish.*

to the chinook in commercial value, being especially important in the Columbia and Fraser rivers and in Alaska. For canning purposes it is but little inferior to the chinook, the color of the flesh being a rich red, which persists after canning. Large quantities are canned in British Columbia and in Alaska, particularly on Kadiak Island, and its commercial importance to that Territory is indicated by the fact that nearly half of the entire salmon pack of the world comes from Alaska and the majority of the fish there canned are of this species. Comparatively few red salmon are sold fresh in the United States.

It is next to the smallest of the salmons, the maximum weight being about 15 pounds, but it rarely weighs over 8 pounds and the average is scarcely 5 pounds. In various lakes this fish weighs only half a pound when mature, and is called the little redfish.

It ranges from Humboldt Bay, California, to the far north. In general it ascends only those rivers which rise in cold, snow-fed lakes. No more is known of its ocean life than of the quinnat. It appears in the Columbia with the spring run of the quinnat. In southern Alaska and at Kadiak Island it comes in numbers in June; the heaviest run is in June and July, the spawning occurring in August and September. In the Idaho lakes, which may be considered typical spawning-grounds for this fish in the United States, the height of the spawning season is from August 25 to September 5, although ripe eggs have been found as early as August 2, and fish with eggs in them as late as September 11. In the numerous affluents of the Fraser River the spawning extends from September 15 to November 15, a few stragglers spawning as late as November 30. They deposit their eggs on gravel in rather shallow water, usually in the inlets of the lakes. The eggs average about 1,000 to 1,200 to the fish.

Except in the breeding season the color of this fish is a clear bright blue above, with silvery sides and belly. At the spawning period the back and sides become red, and the male develops an extravagantly hooked upper jaw.

THE HUMPBACK SALMON.

The humpback salmon (*Oncorhynchus gorbuscha*) is the smallest of the Pacific salmons; its average weight is only 5 pounds, and it rarely reaches 10 pounds. Its range is from San Francisco probably as far north as the Mackenzie River, and it is also common on the Asiatic coast. It is the most abundant and generally distributed salmon in Alaska, but in the Pacific States it does not ordinarily occur in great abundance, although there is sometimes a noteworthy run in the Puget Sound region.

In food qualities the fresh-run humpback is scarcely inferior to any other salmon. While the flesh has a very fine flavor, it is paler than that of other red salmon, and the species has consequently been neglected by canners; but it is probable that it will eventually be utilized for canning purposes, and its excellent qualities when fresh are undoubtedly

destined to give it a great commercial value. Its chief consumption now is by Alaskan natives, who cure large quantities for winter use.

The humpback salmon generally seeks the smaller streams for the purpose of spawning and deposits its eggs a short distance from the sea, sometimes within only a few rods of the ocean. At Kadiak Island, Alaska, where it is often very abundant, it arrives in the latter part of July, the run continuing only a few weeks. Spawning takes place in August.

There are only a few hundred eggs to each fish, the eggs being smaller than those of the quinnat but larger than those of the redfish, and paler in color than the eggs of either of those species.

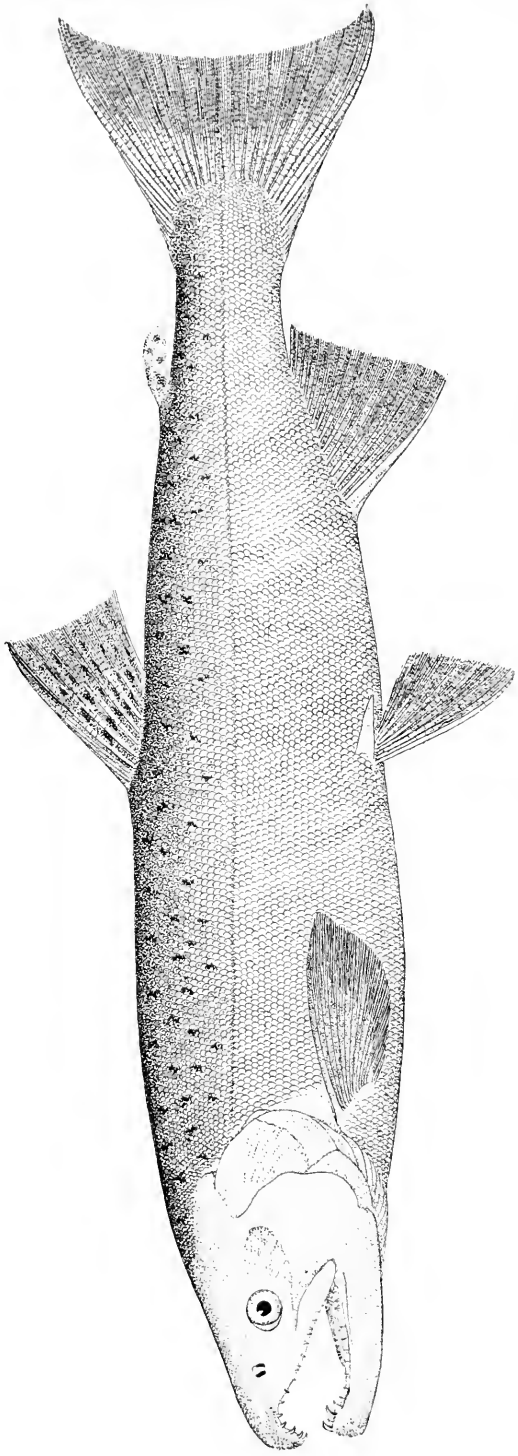
When this salmon first comes from the ocean it resembles a small quinnat, but as the spawning season advances it develops a very large and prominent hump on its back. This, with the distortion of the jaws, gives the fish a very singular appearance. The extreme emaciation and the extensive sloughing of the skin and flesh, which are incident to spawning, result in the death of all the fish, either on the spawning-ground or after being swept out to sea by the current.

THE SILVER SALMON.

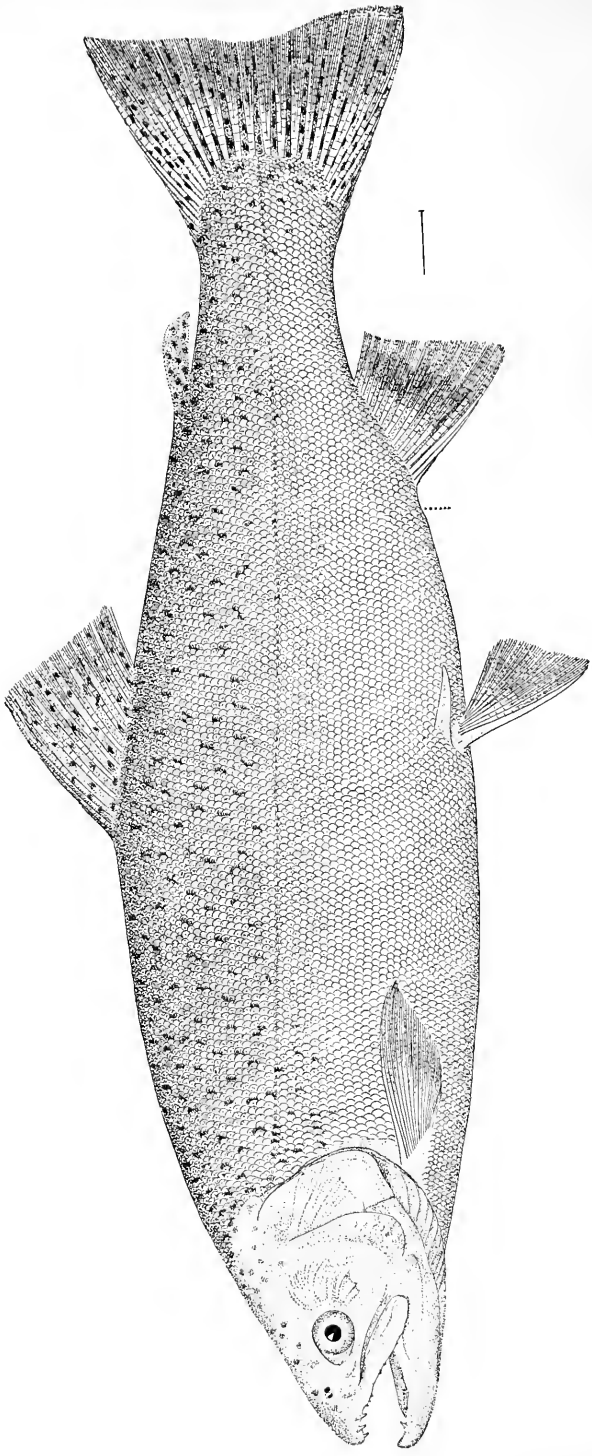
The silver salmon (*Oncorhynchus kisutch*) is also known as silversides, skowitz, kisutch, hoopid salmon, and coho salmon. It is a beautiful fish, having a graceful form and a bright silvery skin. Its flesh, which is fairly good, usually has a bright red color, but as this fades on cooking it is not highly regarded for canning purposes, though large quantities are thus utilized on the Columbia River, Puget Sound, and the short coast streams of Oregon and Washington. Its average weight in the Columbia and Puget Sound is 8 pounds, but in Alaska it averages nearly 15 pounds; it rarely reaches 30 pounds. Its range is from San Francisco to northern Alaska, and as far south on the Asiatic coast as Japan. It runs up the rivers to spawn in fall or early winter, when the waters are high, but usually does not ascend great distances from the ocean. The average number of eggs to a fish is about 2,000.

THE DOG SALMON.

The dog salmon (*Oncorhynchus keta*) is the least valuable of the Pacific salmons, although it is dried in large quantities by the Alaskan natives. Its average weight is 12 pounds and the maximum is about 20 pounds. It is found from San Francisco to Kamchatka, being especially abundant in Alaska. The enlargement and distortion of the jaws give the species a very repulsive look, and the large teeth give to it its common name. When just from the ocean, the flesh has a beautiful red color and is not unpalatable, but it deteriorates rapidly in fresh water. It spawns in shallow rivers and creeks. Larger quantities are utilized in Puget Sound than elsewhere in the Pacific States, and it is also used considerably by the natives of Alaska.



ONCORHYNCHUS KISUTCH. *Silver Salmon.* Breeding male, with distorted jaws.



SALMO GAIRDNERI. *Steelhead.*

THE STEELHEAD.

Another anadromous salmonoid fish found on the Pacific coast, popularly regarded as a salmon, is the steelhead (*Salmo gairdneri*), known also as hardhead, winter salmon, square-tailed trout, and salmon trout. It resembles in form, size, and general appearance the salmon of the Atlantic coast, and is distinguished from other Pacific coast salmon by its square tail, its small head, round snout, comparatively slender form, light-colored flesh, and its habit of spawning in spring. It is more slender than the quinnat and consequently not so heavy for its length. Its average weight in the Columbia is about 10 pounds, although it sometimes reaches 30 pounds.

Its range is very extended, reaching from Santa Barbara on the southern coast of California to the Alaska Peninsula, and perhaps to the Arctic Ocean, and it is found in almost all the streams of the Pacific States which empty into the ocean. It begins to enter the Columbia in the fall, and is then in prime condition. From this time it deteriorates until the following spring, when, between the months of February and May, spawning occurs. Its movements in other rivers on the coast are not materially different, though perhaps it enters the southern rivers earlier and northern rivers later than the Columbia. Like the chinook, the steelhead ascends rivers for long distances, and it has been found almost as far up the tributaries of the Columbia as the ascent of fish is possible. Its eggs are much smaller than those of the chinook and average 3,000 to 5,000 to the fish.

As the greatest quantities of steelheads are caught in the spring, when they are spawning and are in a deteriorated condition, they are not generally esteemed as food; but when they come fresh from the sea and are in good condition, their flesh is excellent. As the demand for salmon has increased, steelheads have been utilized for canning and they have formed a noteworthy part of the canned salmon from the Columbia River for a number of years past, as well as from the short coast rivers of Washington and Oregon. Their consumption fresh has been increasing yearly and considerable quantities have been sent to the Eastern States in refrigerator cars.

ARTIFICIAL PROPAGATION.

The chinook being the principal salmon that has been propagated artificially, the present chapter relates almost entirely to this species. The discussion of the apparatus and methods has special reference to the hatcheries of the Commission on McCloud River and Battle Creek, tributaries of the Sacramento, although cognizance is also taken of the work at the stations in the basin of the Columbia River and on the short coast rivers of California and Oregon.

In 1899 the number of eggs of this fish collected by the Commission was 48,043,000, from which about 43,775,000 fry were hatched and planted. The collections of steelhead eggs numbered 415,000, which produced 85,935 fry.

CAPTURING ADULT SALMON.

The eggs used for artificial propagation are obtained from salmon taken on their way upstream to the natural spawning-grounds. The ascent of the fish is stopped by a heavy wooden rack or barricade and below this obstruction their capture is effected by various means depending on the natural conditions. At Baird station, on the McCloud River, the most practical method of collecting them in large numbers is with drag or sweep seines. These are from 120 to 170 feet long, made of about 28-thread twine, and are 20 feet deep in the middle, tapering down to about 6 feet at the ends; they are double-leaded on account of the swift current of the river, and have a 4-inch mesh.

In the rack are built large wooden traps, in which at times (especially during a rain storm accompanied by a marked rise in the river) large numbers of salmon are taken, but there is never more than a small percentage of spawning fish thus secured. The trap is simply a square inclosure of vertically placed slats, with an entrance similar to that of an ordinary pound net. The fish, in their eager efforts to pass upstream, go through the V-shaped mouth of the trap, and having once entered are not able to find their way out. Boards are placed over the top of the trap to prevent the fish from leaping out.

The trap is quite a valuable auxiliary to the seine, but although it will secure many unripe fish, the ripe ones, which are the ones wanted, finding an obstruction in their way, are apt to settle back to spawning-grounds below and remain there. This may be obviated by building a second rack below the first, which, while permitting the ascent of the fish, is so constructed as to prevent their return.

Large dip nets have been used occasionally at Clackamas station, in Oregon, the fishermen standing on the rack at night and dipping below it. Toward the end of the season this method secures a considerable number of ripe fish, but it involves much labor and expense, and most of the spawning fish taken with the dip nets would probably have been captured in the regular course of fishing. There being no satisfactory seining-grounds at Clackamas, and the river just below the rack being shallow, an Indian method of fishing is used. The aversion of salmon to heading downstream is well known, but when they are very much frightened they will turn around and rush downstream at their utmost speed. The Indians take advantage of this fact and build a dam of rock or wickerwork, or anything that will present an obstruction to the frightened fish. It is shaped like the letter V, with the angle downstream, and at the angle is a large trap into which the fish are driven. This was at one time the principal method of capturing the breeding salmon at Clackamas, and it worked very satisfactorily. Fyke nets and other fish-catching devices have been employed from time to time, but have been rejected as unsatisfactory.

At Baird, before the rack was employed permanently, seine fishing was usually begun after dark and continued throughout the night, but

RACK FOR STOPPING ASCENT OF SALMON, AT BATTLE CREEK, CALIFORNIA.

since the rack has been in use the seine has been hauled more or less in the daytime with perfectly satisfactory results, the fishing generally commencing about 4.30 a. m. and continuing as long as the results warrant it. The work is resumed again about 5 o'clock in the afternoon and continued as long as it meets with success.

CONSTRUCTION OF THE RACK.

This obstruction consists of a fence placed across the river and supported by piers heavy enough to prevent the force of the current from pushing them out of position. Log stringers, from 8 to 15 inches in diameter, are laid from pier to pier, to which they are securely pinned, and posts, from 2 to 4 inches in diameter and of the required length, are driven obliquely into the bed of the river, the lower ends being 3 or 4 feet upstream, the upper ends resting on the stringers. Against these posts is laid the rack, which is made in sections, each 6 to 10 feet long, the slats which form them being $1\frac{1}{4}$ inches thick and 3 inches wide, and securely braced at top and bottom. The slats are set $1\frac{1}{2}$ inches apart, and are beveled on the upper side in order to present less resistance to the current. The space between the slats allows ample room for water to go through, but prevents any salmon from ascending. A wider space between the slats would be preferable, as creating less obstruction to the current, but it would allow a considerable percentage of small grilse (the young salmon after its first return from the sea) to get by the rack, and unless the older males are quite plentiful the grilse are likely to be needed when the spawning season arrives.

The piers, when first made, are hollow triangles of heavy logs, each layer of logs being firmly pinned to the one below it, until the required height is reached, the apex of the triangle pointing upstream. They are afterwards filled with rocks and are very substantial. Those on the McCloud have been able to withstand the tremendous momentum of the current, even in the highest water.

TAKING AND IMPREGNATING THE EGGS.

After salmon are secured by the seine or other means, they are, for convenience in handling, placed in pens or live-boxes made for this purpose, the ripe or nearly ripe males and females being kept separate. Where the eggs are taken on a large scale, it is desirable to have separate compartments for ripe males, ripe females, nearly ripe females, and males partially spent that it may be necessary to use again, and one or two spare compartments are found to be convenient where large numbers of fish are handled.

Stripping the fish is usually done every day, as the eggs of the females confined in the pens are likely to be injured within the fish, which is a serious objection to keeping the parent fish in confinement any longer than is absolutely necessary.

Of the signs that usually accompany ripeness in a female salmon, the separation of the eggs in the ovaries is the surest, but the spawn-

taker relies rather on a general appearance which is neither color, shape, nor condition of organs, but which shows at a glance that the fish is ripe and can be appreciated only by experience.

Spawning operations are conducted upon a floating platform, beneath which are compartments for retaining the ripe fish, and which are accessible through hinged covers set in the plank flooring. Projecting beyond this platform is another, upon which the actual work of stripping the fish and caring for the pans is performed.

When taking the eggs, one or two men stand ready with dip nets to hand the females to the spawn-taker, and one or more perform the same office with the males. After the salmon are taken from the pens they are held suspended in the net until their violent struggles are over, after which they become quiet enough to be handled and the eggs and milt can be expressed easily.

All methods of taking salmon spawn are very much the same, there being only slight differences in details, chiefly in the manner of holding the parent fish and impregnating the eggs. Where there are plenty of assistants and the salmon are of medium size, the most expeditious way is for the man who takes the spawn to hold the female in one hand and press out the eggs with the other, another in the meantime holding the tail of the fish. The male is handled in the same way.

The above method is employed at Baird, but on the Columbia River, where the salmon are larger and are harder to manage, the "strait-jacket," as it is called, is used; this is a sort of a trough made about the average length of the salmon and hollowed out to fit its general shape. Across the lower end is a permanent cleat, and at the upper end is a strap with a buckle. The fish, when manipulated, is slid into the trough, the tail going down below the cleat, where it is securely held, and the head is buckled in at the upper end with the strap. It is now unable to do any harm by its struggles and the eggs can be pressed out at leisure. The strait-jacket is almost indispensable with the very large salmon and is a very great convenience when the operators are limited in number.

In impregnating the eggs the main object is to bring the milt and the eggs together as quickly as possible after they have left the fish. By some persons a little water is considered desirable to give greater activity to the milt, but if left more than a minute in the water there is a decided loss of fertilizing power. The eggs do not suffer so quickly from immersion in water. The absorbing property which they possess when they first leave the parent fish, and which attracts to the micropyle the spermatozoa, lasts several minutes, but it is not prudent to leave the eggs in the water a moment longer than is necessary before adding the milt.

The addition of the water is not essential to a good impregnation; in some instances better results are secured without the use of water and, after all, if the main object is secured, of bringing the milt and

TAKING SALMON EGGS AT LITTLE WHITE SALMON STATION.

FERTILIZING SALMON EGGS.

SALMON IN STRAIT-JACKET.

the eggs together with the slightest possible delay after they leave the fish, it makes very little difference whether water is used or not. The milt retains its fertilizing power several days when kept from air and water, and impregnation can be effected between fishes widely separated by merely forwarding the milt properly sealed. At Baird impregnation by the dry method, which has always been followed there, has resulted in the fertilization of about 90 per cent of the eggs so treated.

The Russian or dry method of impregnating eggs consists simply in taking both the eggs and the milt in a moist pan. It may be urged as an objection to this method that the eggs will be injured by striking against the pan, but it is a fact that although the same eggs would be destroyed by the concussion a week later, or even 24 hours later, they do not suffer in the least from it at the moment of extrusion from the fish.

It was at one time considered an important question whether the eggs or milt should be taken first, but with the dry method it makes no difference, as, either way, both eggs and milt remain operative long enough for all practical purposes of impregnation.

Various methods of treating the eggs in the pan after impregnation has taken place have been tried. Some operators leave the eggs in the pans as first taken with the milt for two or three minutes and then add water, after which they are left to stand in the pan until they separate, when they are washed clean, taken to the hatching-house, and placed in the troughs. Others pour the contents of the several pans—eggs, milt, and all—into a large can after the eggs become impregnated, and when the eggs separate the contents of the can are poured into the hatching-troughs, trusting to the current in the troughs to wash the milt from the eggs. At Baird, water is poured on the eggs a few moments after they become impregnated, after which they are left perfectly quiet until they separate, which in water of the temperature of the McCloud River in September, 52° to 53°, takes about an hour. The pans, in the meanwhile, are put in a trough filled with river water to keep them from becoming too warm. After the eggs separate they are carefully washed and are carried in buckets to the hatching-house, where they are measured and placed in the hatching-trays.

The methods of taking and fertilizing eggs at Clackamas are as follows: The female fish to be operated upon is taken from a floating pen and is placed in the spawning-box or "strait-jacket"; a male fish is then caught and tied with a small rope around its tail to some part of the corral where he can be quickly caught when needed. One man presses the eggs from the female securely held in the spawning-box, the pan for receiving these being held by another. As soon as the eggs are taken, the male is drawn from the pen by the rope and held by one man, who takes it by the tail with his left hand, its head between or across his knees. With his right hand the milt is then pressed from the fish into the pan containing the eggs as soon as possible after they are taken.

The eggs are taken in a pan without any water and milt enough is used to insure its coming in contact with each egg. After the eggs and milt are obtained the pan is gently tilted from side to side and the mass of eggs and milt stirred with the fingers until thoroughly mixed. The pan is then filled about two-thirds full of water and left until the eggs separate, the time varying from 1 to 1½ hours, according to the number of eggs and the condition of the atmosphere.

The eggs of the quinnat salmon are of a deep salmon-red color and are heavier than water. In size they average about $\frac{4}{16}$ or $\frac{5}{16}$ of an inch, from 12 to 18 being covered by a square inch. The number in a quart is about 3,700. Probably 90 per cent of the eggs taken are impregnated on an average, though the results vary with different seasons, places, and methods of handling.

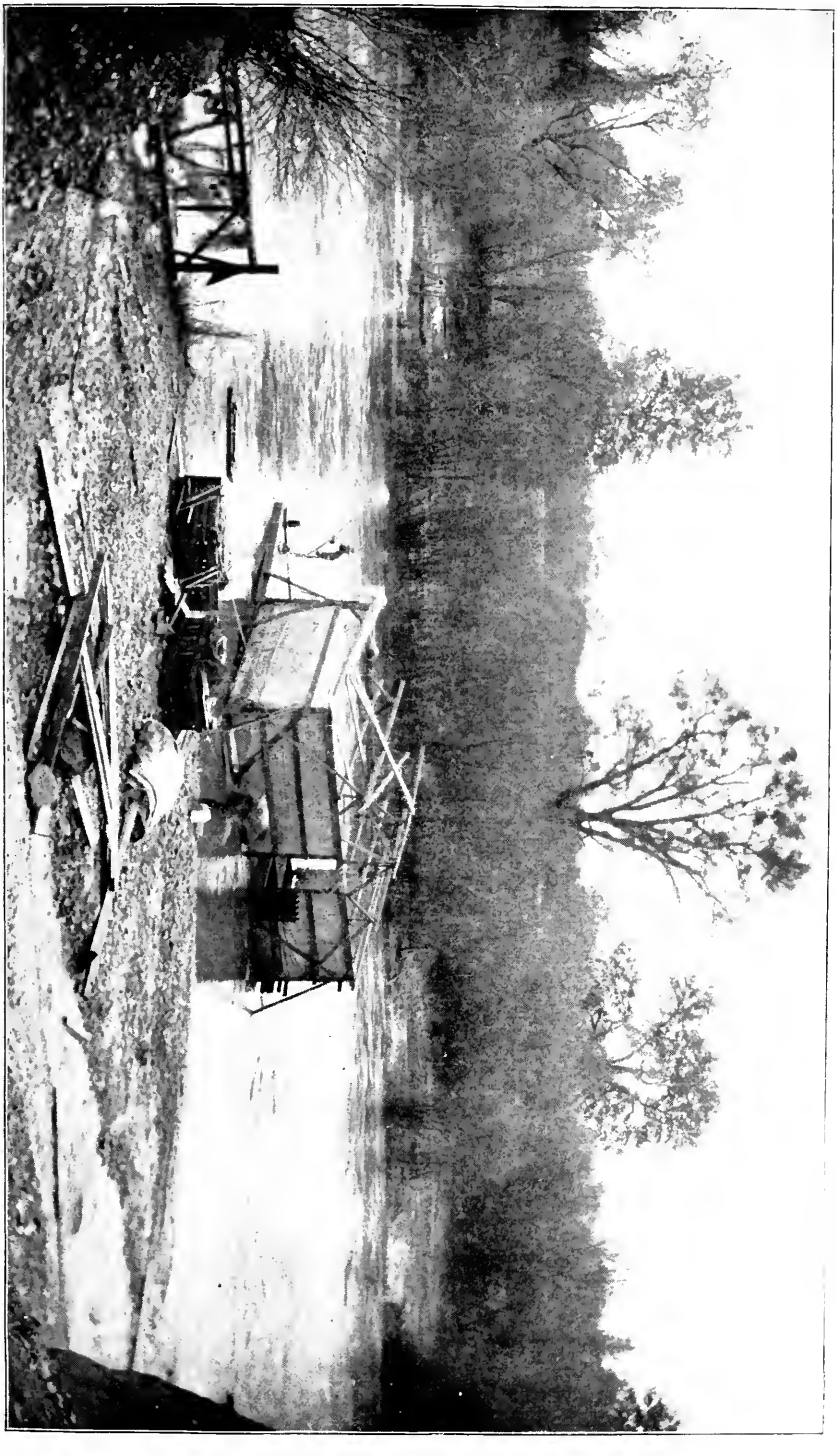
HATCHING APPARATUS AND METHODS.

The hatching apparatus generally employed on the Pacific coast in salmon propagation consists of a combination of troughs and baskets. The troughs in common use are the so-called "Williamson troughs," which are 16 feet long, 12 or 16 inches wide, and 6½ inches deep. The troughs are arranged in pairs, and usually two or three pairs are placed end to end on different levels. The fall of water in each trough is 1½ inches. The troughs are divided by double partitions of wood or metal into compartments just enough longer than the baskets to enable the latter to be raised and lowered and to be tilted slightly. The essential feature of these troughs is that at the lower end of each compartment a partition, extending entirely across the trough, reaches from the bottom almost to the top, and another similar partition at the upper end of the compartment reaches from the top almost to the bottom of the trough, each set of partitions being about an inch apart. The water is consequently forced to flow under the upper partition and over the lower partition, and to do this it must necessarily ascend through the tray of eggs. The troughs are provided with canvas covers stretched upon light frames, and made sunlight proof by saturation with asphaltum varnish, and their interiors are thickly coated with asphaltum.

The egg receptacles are wire trays or baskets about 12 inches wide, 24 inches long, and deep enough to project an inch or two above the water, which is 5 or 6 inches deep in the troughs in which they are placed. Into each of these baskets 2 gallons of salmon eggs, equivalent to about 30,000, are poured at a time. The eggs suffer no injury whatever from being packed together in this manner, the water being supplied in a way that forces it through the eggs, partially supporting and circulating through them. The meshes are too small to permit the eggs to pass through, although the fry are able to do so.

The advantages of this apparatus and method are:

(1) The top of the tray or basket is out of the water and always entirely dry; consequently, in handling it, the hands are kept dry.



PENS FOR HOLDING RIPE FISH, AND STRIPPING PLATFORM, AT BATTLE CREEK, CALIFORNIA.

(2) By tilting one end of the tray up and down a little or by lifting it entirely and settling it gently back again in its place the bad eggs will be forced to the top; thus a feather is not required in picking over the eggs and the injuries very often inflicted with it are avoided.

(3) The top of the tray being above water, the eggs can never run over the top nor escape in any way, which is a great advantage over the shallow form of tray.

(4) There is economy of space; 30,000 to 40,000 eggs can be placed in each basket, provided a sufficient quantity of water is available. Two troughs, 16 feet long and 1 foot wide, will by this method carry about 500,000 salmon eggs. The deep trays may be filled at least half full of eggs, and thus ten times as many eggs can be hatched in the same space and with the same supply of water as by the old method. A good but gentle circulation is continually maintained through the eggs.

(5) The deep-tray system is admirably adapted to getting rid of mud that has collected on the eggs, for all sediment accumulating about them can be easily removed by gently moving the tray up and down a few times in the water; but if the deposit of mud on the troughs becomes so excessive as to be unmanageable, a false bottom of wire cloth or perforated zinc can be placed in the troughs at a suitable distance above their real bottom, leaving a space of about 1 or 1½ inches between the wire cloth and the trough bottom. By this means the mud that comes into the trough will sift down into the space below the wire cloth entirely out of the way of the fish, the movements of the fish themselves helping very much to produce this result. Should the accumulation of mud in the space below the false bottom of the trough become too great, it can easily be sluiced out in various ways.

When quinnat-salmon eggs are simply to be matured for shipment, hatching trays with ¼ or ⅓ inch square mesh will answer the purpose, but when the eggs are to be hatched in them, every alternate strand of wire running lengthwise, or, better still, every second and third thread should be left out in order to form an oblong mesh through which the newly hatched fry, after separating themselves from the unhatched eggs, can escape from the hatching trays into the trough below.

At Baird eggs kept in water averaging about 54° F. hatch in 35 days. The allowance of 5 days' difference in the time of hatching for each degree of change in the water temperature is approximately correct.

For the first few days the eggs of the quinnat salmon are very hardy, and at this time they should be thoroughly picked over and the dead ones removed as far as possible before the delicate stage during the formation of the spinal column comes on, so that during that critical period they may be left in perfect quiet. As soon as the spinal column and the head show plainly, the eggs are hardy enough to ship, but when there is time enough it is better to wait a day or two until the eye-spot is distinctly visible, after which time the eggs will stand handling and may be safely shipped if properly packed.

PACKING EGGS FOR SHIPMENT.

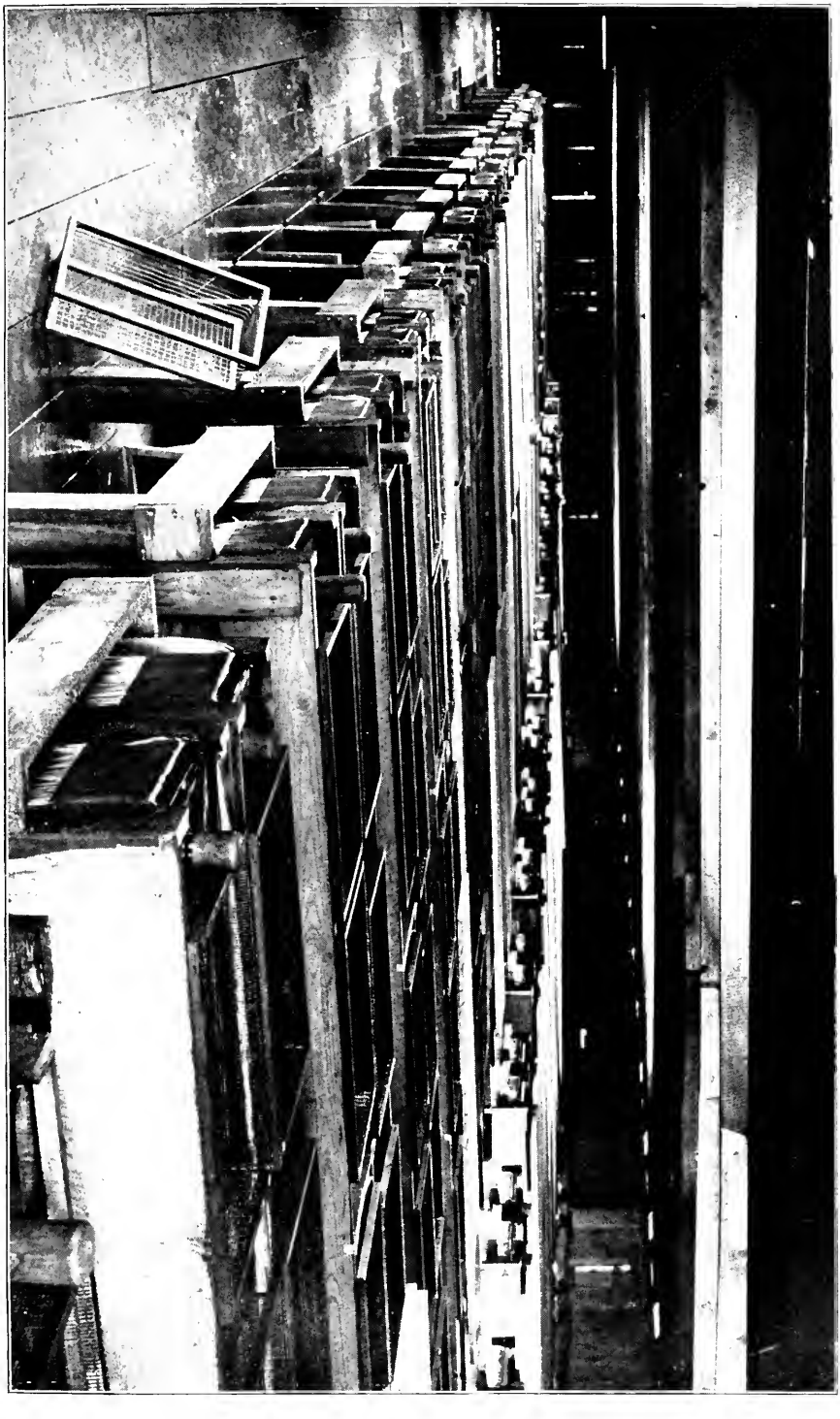
The packing-box used in shipping salmon eggs is made of ½-inch pine, 2 feet square and 1 foot deep. At the bottom is placed a thick layer of moss, then a layer of mosquito netting, then a layer of eggs, then mosquito netting again, then successive layers of moss, netting, eggs, netting, and so on to the middle of the box. Here a firm wooden partition is fastened in and the packing renewed above in the same manner as below. The cover is then laid on the top, and when two boxes are ready they are placed in a wooden crate, made large enough to allow a space of 3 inches on all sides of the boxes. This space is filled with hay to protect the eggs against changes of temperature, and the cover being put on the eggs are ready to ship. In the middle of the crate an open space about 4 inches in depth is left, between the two boxes of eggs, for ice. As soon as the crates arrive at the railway station this space, as well as the top of the crate, is filled in with ice. Recent experiments show that salmon eggs can be packed and safely transported to considerable distances when they are first taken.

CARE OF THE FRY.

The eggs of quinnat salmon, like those of the other *Salmonidæ*, hatch very gradually at first, only a small proportion of fish coming out the first day; but the number increases daily until the climax is reached, when large numbers of young burst their shells in a single day. At this time great care and vigilance are required. The vast numbers of shells rapidly clog up the guard-screens at the outlets of the troughs, which should be kept as free as possible by thoroughly cleansing them from time to time.

In the deep trays the newly hatched fish are mixed with unhatched eggs, and the advantage of the oblong mesh in the bottom of the trays becomes apparent. This mesh is too narrow to allow the eggs to fall through, but the hatched fish, being comparatively long and narrow, easily slip down through the long meshes into the space below. They should be assisted by gently raising and lowering the tray at intervals, care being taken not to raise them out of the water, as at this tender age a slight pressure against the wire of the tray will often produce fatal injuries. On this account too much caution can not be exercised in regard to handling them out of water during the first stages of the yolk-sac period, for the injuries can not be seen at first, and often the death of the fry is the first warning that they have been injured.

After the eggs are all hatched and the young fish are safely out of the trays and in the bottom of the troughs, their dangers are few and they require comparatively little care. Almost the only thing to be guarded against now is suffocation. Even where there is an abundance of water and room, with a good circulation, they often crowd together in heaps or dig down under one another until some of them die from want of running water which is not an inch away from them. The best remedy in such a case is to thin them out.



INTERIOR OF HATCHERY AT BATTLE CREEK, SHOWING SALMON BASKET.

Eight thousand gallons of water an hour is sufficient for ten lines of troughs 64 feet in length, containing altogether a little over 1,000,000 young salmons in the yolk-sac stage. This gives in round numbers 800 gallons of water to each 100,000 fry every hour, or 16⅔ gallons per minute, which is a safe minimum.

FEEDING AND PLANTING THE FRY.

When the yolk-sac has become nearly absorbed the fish rise from the bottom of the trough, where they have previously remained, and begin swimming. They are now almost ready for food and must be liberated unless artificial food is provided. As a rule the fry are planted about the time the yolk-sac is absorbed. This is regarded as the best practice, and moreover the amount of space required renders the rearing of fry in large numbers impracticable. They have, however, been successfully retained in troughs in small numbers from the time they begin to feed in February until the middle of May, when on account of the rising temperature of the water they are liberated. They show when they are ready to feed by darting to one side or the other when small particles of food are dropped in the water and floated past them. From this time, for several weeks, the necessity for care and vigilance never ceases. For the first few weeks they should be fed regularly and as often as six times a day, and the earlier in the day the feeding begins and the later it continues at night the better. Two hours after feeding they will be found to be ravenously hungry, and they grow much faster for frequent feeding and get that growth in their infancy which is indispensable to their ultimately attaining the largest possible size. If not fed sufficiently they will bite at one another and cause more or less mortality among themselves.

The best food for salmon fry is some kind of meat, finely pulverized. Boiled liver is especially good for this purpose, partly because it is inexpensive and easily obtainable, and also because it can be separated into very fine particles. Raw liver is also excellent and may be reduced into as fine particles as the cooked liver by grinding or chopping and then properly straining it through a fine-mesh screen. The yolk of boiled eggs is also suitable, but is much more expensive than liver and is not so good for the fish as liver, unless largely mixed with it.

As the fish grow older they continue to thrive best on meat food, but, if that is not always obtainable in sufficient quantities or on account of its expense, a very good substitute is a mixture of shorts or corn meal with the meat. This is prepared as a mush by stirring shorts or middlings into boiling water, a little at a time, so that it will not cook in lumps, but become more of a paste. After it has thoroughly cooked it is allowed to cool and harden. The best proportion is 30 pounds of shorts to 25 gallons of water with 3 or 4 pounds of salt. The percentage of liver to be used in this mixture should be regulated by the age of the fish, feeding the very young fry upon almost a simple meat diet and gradually increasing the proportion of mush.

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